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Liu, C.T., "Investigating Cumulative Damage in a Highly Filled Polymeric Material"

Abstract for 2001 Joint Applied Mechanics and Materials Summer Conf. **(Statement A)**
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Investigating Cumulative Damage in a Highly Filled Polymeric Material

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A highly filled polymeric material, which consists of a large number of fine particles, on the microscopic scale, can be considered nonhomogeneous. When this material is stretched, the different sizes and distribution of the filler particles, the different crosslinking density of the polymer chains, and the variation of the bond strength between the particles and the binder can produce highly nonhomogeneous local stress and strength fields. Because of the particle's high rigidity relative to the binder, the local stress is significantly higher than the applied stress, especially when the particles are close to each other. Since local stress and strength vary in a random fashion, the failure site in the material also varies randomly and does not necessarily coincide with the maximum stress location. In other words, the location and degree of damage will also vary randomly in the material. The damage may appear in the form of microcracks and microvoids in the binder, or in the form of particle/binder separation known as dewetting. When the particle is dewetted, the local stress will be redistributed. With time, additional particle/binder separation and vacuole formation takes place. This time-dependent process of dewetting nucleation, or damage nucleation, is due to the time-dependent processes of stress redistribution and particle/binder separation. Depending on the formation of the material and the testing condition, damage growth may take place as material tearing or by successive nucleation and coalescence of the microvoids. These damage initiation and evolution processes are time-dependent, and are the main factors responsible for the time-sensitivity of the strength degradation as well as the fracture behavior of the material.

In this study, a damage parameter, based on a linear cumulative theory, was used to determine the damage state in the material under constant strain rate and dual-strain rate loading conditions. During the tests, volume dilatations were measured. The relationships among the damage parameter, volume dilatation, and the constitutive behavior of the material were investigated. In addition, ultrasonic techniques were used to measure the relative ultrasonic attenuation coefficient, α, as a function of the applied strain under constant strain rates and cyclic loading conditions. The characteristics of internal damage, measured in terms of α, were determined. Also, a time-dependent cumulative damage model under constant strain rate condition was developed and the applicability of using this model to predict damage was discussed.